CHAPTER III
SUMMARY INFORMATION

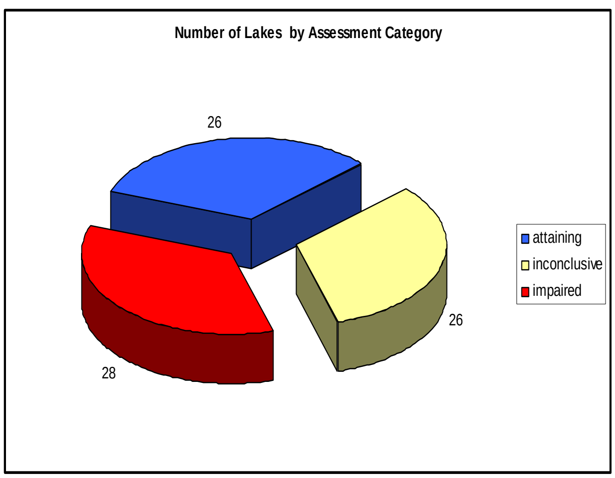
This chapter provides a summary of assessed surface waters. Progress and comparisons with previous assessments are illustrated in the following chapter. Statewide summary statistics can provide a general sense of the status of water quality in Arizona.

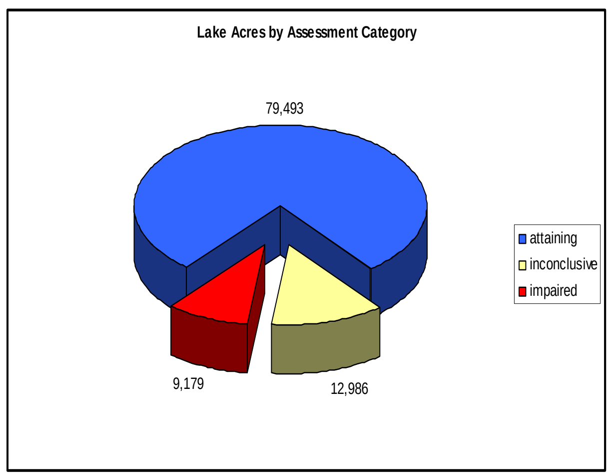
The assessments and statistics in this chapter exclude surface waters on tribal lands. Also, the statistics *include* waters that EPA listed in previous assessment.

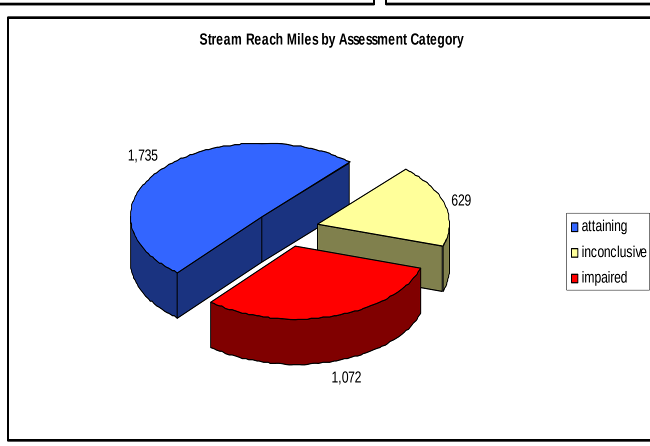
Attaining or Impaired Waters

Assessed Waters 2006/2008

USE SUPPORT CATEGORY	LAKES (Acres)	STREAMS (Miles)
Attaining Uses (Category 1 and 2)	79,493	1,735
Impaired (Category 4 and 5)	9,179	1072
Inconclusive (Category 3)	12,986	629
Total Assessed	**101,658**	**3,435**
Total Assessed as Attaining or Impaired (excluding Category 3)	88,672	2,806







About 78% of the lake acres and 50% of the stream miles assessed are attaining their uses.

If sites had been randomly selected across the state, this could be used to infer water quality throughout Arizona. However, sites are not randomly selected. They were selected by different programs and agencies for a variety of purposes, some with a bias towards finding pristine or impaired conditions. Therefore, inferences about water quality in general in Arizona should be limited. (See future monitoring discussion in Chapter IV.)

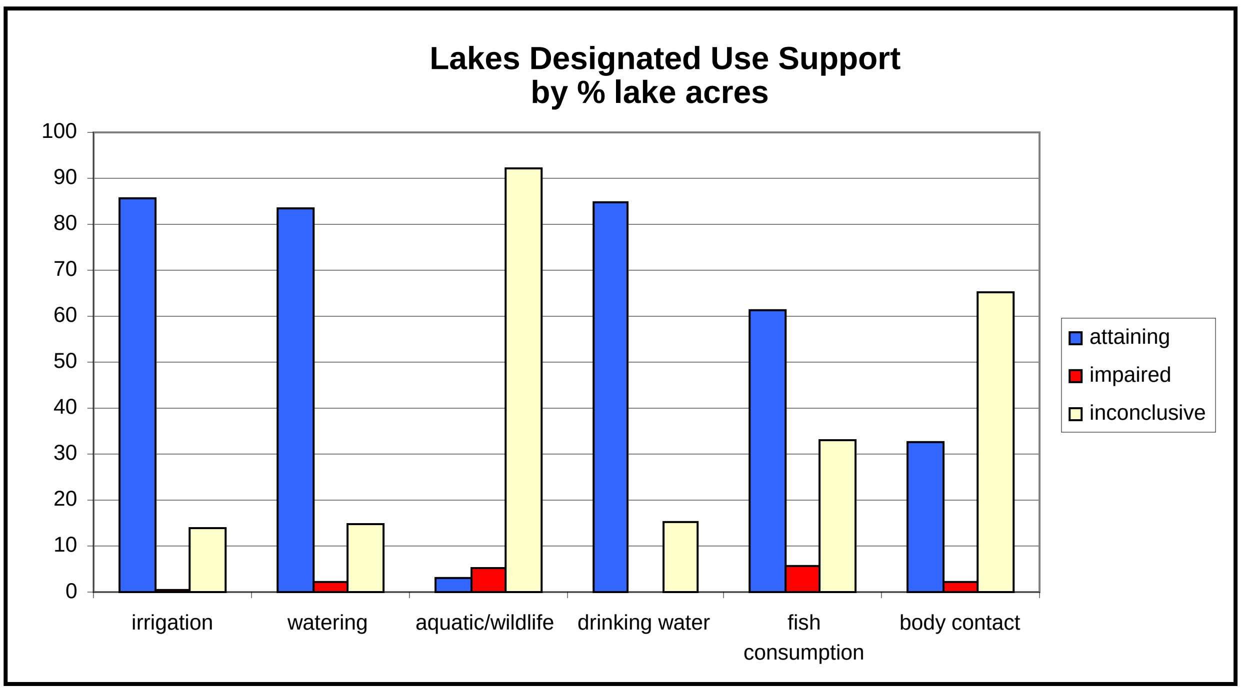
Designated Use Support – Narrative and numeric criteria were developed to protect uses shown to be occurring on a surface water – aquatic life, swimming, fishing, drinking water supply – therefore, designated use support should indicate whether our water is safe for use. (See explanation of standards and designated uses in the Assessment Methods document.)

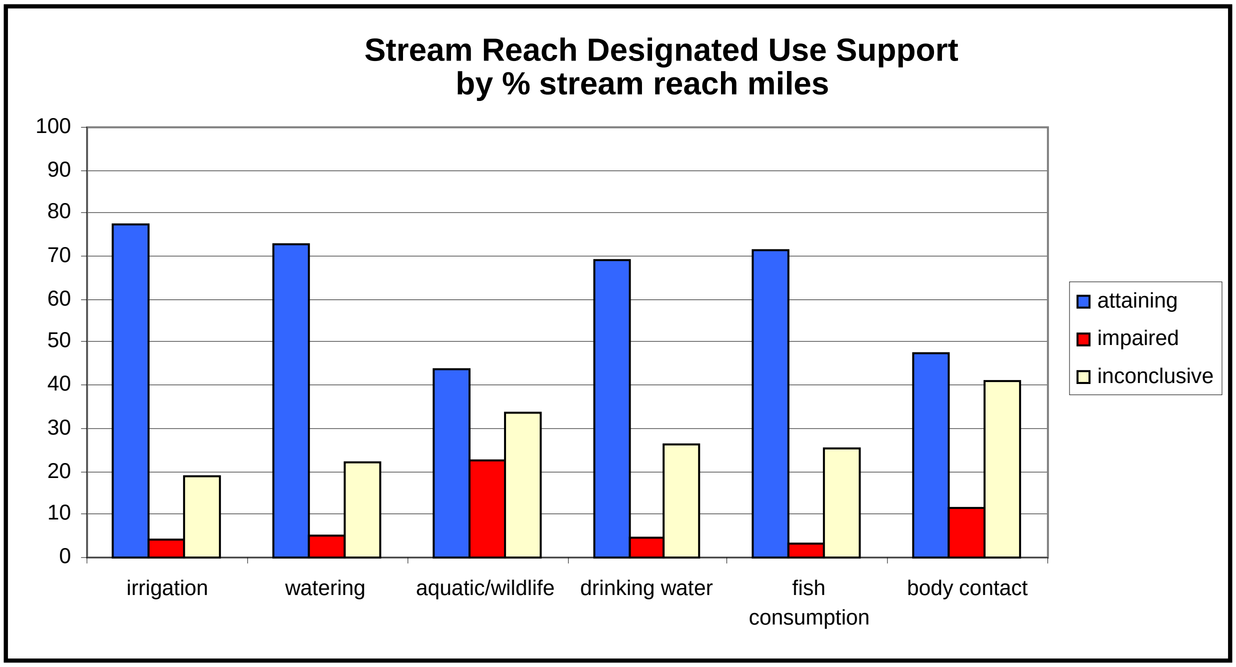
The following table and graph illustrate the relative use support for each of the designated uses.

Designated Use Support Statistics – 2006/2008

SUPPORT TYPE	LAKES				STREAMS		
	Attaining (acres)	Impaired (acres)	Total (acres)		Attaining (miles)	Impaired (miles)	Total (miles)
Aquatic and Wildlife	3,024	5,152	101,658		1,491	765	3,406
Fish Consumption	62,417	5,626	101,658		2,316	100	3,236
Body Contact	33,250	2,040	101,658		1,616	393	3,406
Dom. Water Source	60,214	0	71,112		388	26	562
Irrigation	82,949	417	96,990		1,403	72	1,815
Livestock Watering	83,891	2,004	100,542		2,122	150	2,918

**Total* miles and acres include miles and acres assessed as "inconclusive."





These statistics can be used to answer the following questions:

- **Is it Safe for Aquatic and Wildlife Uses?** – Aquatic life is most at risk due to degraded water quality, as the fish and other aquatic critters are living in the water. This is reflected in surface water quality criteria, as water quality criteria are frequently more protective (lower criteria were established) than even human health criteria. In this assessment, therefore, the aquatic life use has the lowest percentage of attainment and the highest percentage of impairment. This indicates that protection of aquatic life is generally fair in the waters assessed as 11% of the lakes and 40% of the streams are attaining this use. However, these water quality criteria are the most likely to be exceeded and result in impairment -- 5% of the lakes and 22% of the streams.

  Several large reservoirs were assessed as inconclusive when it came to this use, resulting in an unusually low proportion of attaining and impaired lake acres. These reservoirs, Lake Mohave, Lake Powell, Lake Havasu, and Roosevelt Lake, account for nearly 80% of assessed lake acres.
  Lakes Mohave and Havasu in the Colorado-Lower Gila watershed were inconclusive due to selenium concerns, while Lake Powell in the Colorado-Grand Canyon lacked core parameter monitoring. Roosevelt Lake in the Salt watershed lacked core nutrient parameters. More monitoring is planned for all of these reservoirs, and new narrative nutrient implementation guidance will be applied to the Salt River reservoirs by the next assessment.

  When it comes to streams, the primary cause of impairment was selenium, which can be found in local bedrock at natural high levels in some areas of the state. More studies will be done in association with TMDL development to determine whether or not the loadings are natural.

- **Is it Safe to Swim in the Water?** – Full Body Contact (swimming) or Partial Body Contact (wading) was shown to be attaining in 28.6% of the lakes and 46.0% of the streams assessed. The cause of impairment for this use in 10.9% lakes and 50.7% of streams is due primarily to *Escherichia coli* bacteria contamination.

  Studies suggest that swimming should be avoided during storm water runoff and in stagnant water where bacteria contamination is likely. Waters classified as “effluent dependent waters” and many shallow urban lakes are also not designated for swimming or even wading.

Routine bacteria monitoring occurs at a few frequently visited swimming areas:

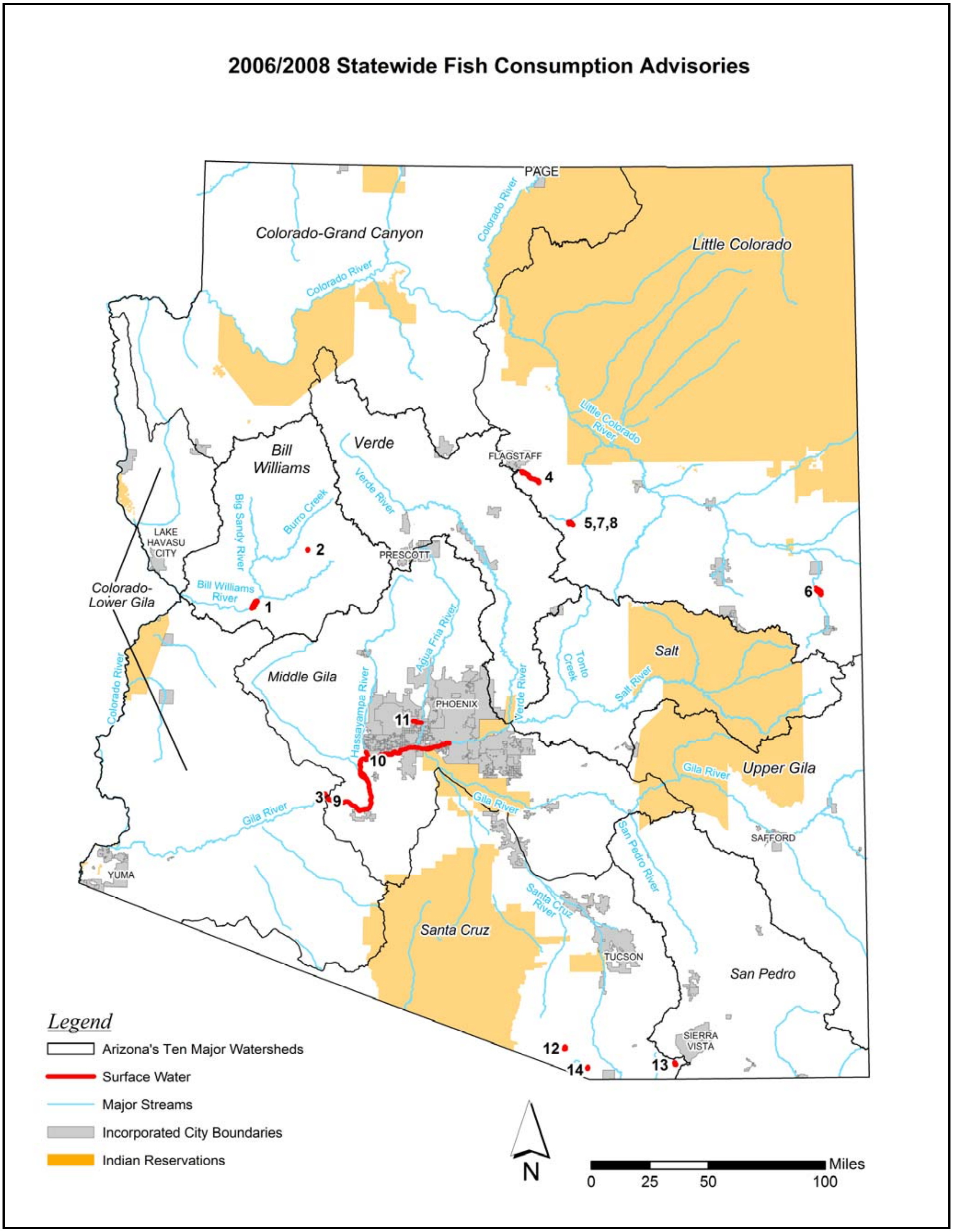
- Slide Rock State Park on Oak Creek,
- Beaches along Lake Havasu,
- Beaches along Lake Powell, and
- The Salt River Recreation Area (for part of this assessment period).

Of these monitored beaches, only Slide Rock state Park closed for swimming during the assessment period due to bacterial contamination. Slide Rock closes its swimming area when sampling results exceed water quality standards and the area remains closed until standards are met. (See TMDL discussion in the Verde Watershed.)

- **Should We Eat The Fish?** – Fish consumption advisories have been issued in 14 areas (see table below). These advisories are issued to inform the public about possible adverse health effects and they contain recommendations for how many fish meals can safely be consumed. Advisories may be directed at a specific subset of the population because some people are at greater risk (pregnant women and children). Additional information about fish tissue screening and fish advisories can be obtained by contacting ADEQ at (602) 771-4536 or Arizona Game and Fish Department at (602) 789-3260.

Fish Consumption Advisories (2006/2008)

SURFACE WATER	SIZE	POLLUTANT AND PROBABLE SOURCES	ADVISORY AND DATE ISSUED
Bill Williams Watershed			
1. **Alamo Lake**	1414 acres	Mercury. Mining and atmospheric deposition	2004. Meal = up to 8 ounces of largemouth bass or black crappie • Children under age 6: no consumption • Women of childbearing age: 1 meal/month • Women not childbearing age: 5 meals/month • Adult men: 6 meals/month
2. **Coors Lake**	229 acres	Mercury. Mining and atmospheric deposition.	2004. Meal = up to 8 ounces of largemouth bass or black crappie • Children under age 6: no consumption • Women of childbearing age: 1 meal/month • Women not childbearing age: 5 meals/month • Adult men: 6 meals per month
Colorado – Lower Gila Watershed			
3. **Painted Rock Borrow Pit Lake**	185 acres	DDT metabolites, toxaphene, and chlordane from historic pesticide application on agricultural lands.	1991. Do not consume fish and other aquatic organisms
Little Colorado Watershed			
4. **Lake Mary, Upper & Lower**	1625 acres	Mercury. Atmospheric deposition	2002 Do not consume walleye fish and limit consumption of other fish to one 8-ounce fillet per month.
5. **Long Lake**	594 acres	Mercury. Atmospheric deposition	2003. Do not consume fish.
6. **Lyman Lake**	1500 acres	Mercury. Atmospheric deposition.	2004. Meal = up to 8 ounces fish • Children under age 6: no consumption • Women of childbearing age and children under age of 16: 1 meal/month • Women not childbearing age: Consult health care provider • Adult men: 5 meals/month
7. **Soldiers Lake**	28 acres	Mercury. Atmospheric deposition	2003 Do not consume fish
8. **Soldiers Annex Lake**	122 acres	Mercury. Atmospheric deposition	2003. Do not consume fish.
Middle Gila Watershed			
9. **Painted Rocks Reservoir**	100 acres	DDT metabolites, toxaphene, chlordane from historic pesticide application on crops	1991. Do not consume fish and other aquatic organisms
10. **Portions of the Gila, Salt, and Hassayampa rivers**	140 miles	DDT metabolites, toxaphene, chlordane from historic pesticide application on crops.	1991. Do not consume fish and other aquatic organisms
11**. Dysart Drain (drains to Agua Fria River in Phoenix metropolitan area)**	3 miles	DDT metabolites. From historic pesticide application on crops.	1995 Do not consume fish or other aquatic organisms.
Santa Cruz Watershed			
12. **Arivaca Lake**	120 acres	Mercury. Mine tailings and atmospheric deposition	1996. Do not consume fish or other aquatic organisms.
13**. Parker Canyon Lake**	130 acres	Mercury. Sources to be investigated.	2002 • Women of childbearing age and children under 16: no consumption • Women not of childbearing age: Consult health care provider. • Adult men (above 15): Up to five 8-ounce meals/month.
14. **Pena Blanca Lake**	50 acres	Mercury. Sources historic mining and atmospheric deposition	1995 Do not consume fish or other aquatic organisms.


2006/2008 Statewide Fish Consumption Advisories
PAGE
Colorado-Grand Canyon
Colorado River
Little Colorado
Little Colorado River
Verde
Bill Williams
FLAGSTAFF
4
Verde River
Big Sandy River
Burro Creek
5,7,8
LAKE HAVASU CITY
2
PRESCOTT
Colorado-Lower Gila
Bill Williams River
1
6
Salt
Tonto Creek
Salt River
Agua Fria River
Middle Gila
Hassayampa River
Verde River
PHOENIX
11
10
Gila River
Upper Gila
3
9
Gila River
San Pedro River
SAFFORD
YUMA
Santa Cruz River
Santa Cruz
TUCSON
San Pedro
Legend
Arizona's Ten Major Watersheds
Surface Water
Major Streams
Incorporated City Boundaries
Indian Reservations
12
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SIERRA VISTA
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A national fish consumption advisory has also been issued by EPA. This advisory recommends that pregnant women (or who may become pregnant), nursing mothers, and young children should limit fish consumption. The women should limit fish to one six-ounce meal per week (8 ounces uncooked fish) and the young children to one two-ounce meal per week. (See further discussion of mercury later in this chapter.)

- **Can We Drink the Water?** – Of the waters assessed, only 0.04% of the lakes and 4.61% of streams were impaired and 83.2% of the lakes and 69.2% of the streams were attaining this use. Keep in mind that these samples were of the source water (the raw water) and do not reflect the quality of water being provided at the tap to the customer. At a minimum, surface water must be disinfected and filtered before it is used for drinking.

  The quality of water delivered by public water systems is strictly regulated and monitored to ensure that federal and state standards established to protect public health are met. Drinking water advisories are issued by the supplier when monitoring confirms that a drinking water standard has been exceeded. Contact the supplier to request a consumer confidence report to learn more about the quality of your public drinking water system.

  When water is supplied by a private water system (a system serving fewer than 15 connections and 25 people), it is the user's responsibility to test and protect the quality of their drinking water. General water quality information and ways to protect drinking water sources can be obtained by contacting a county health department.

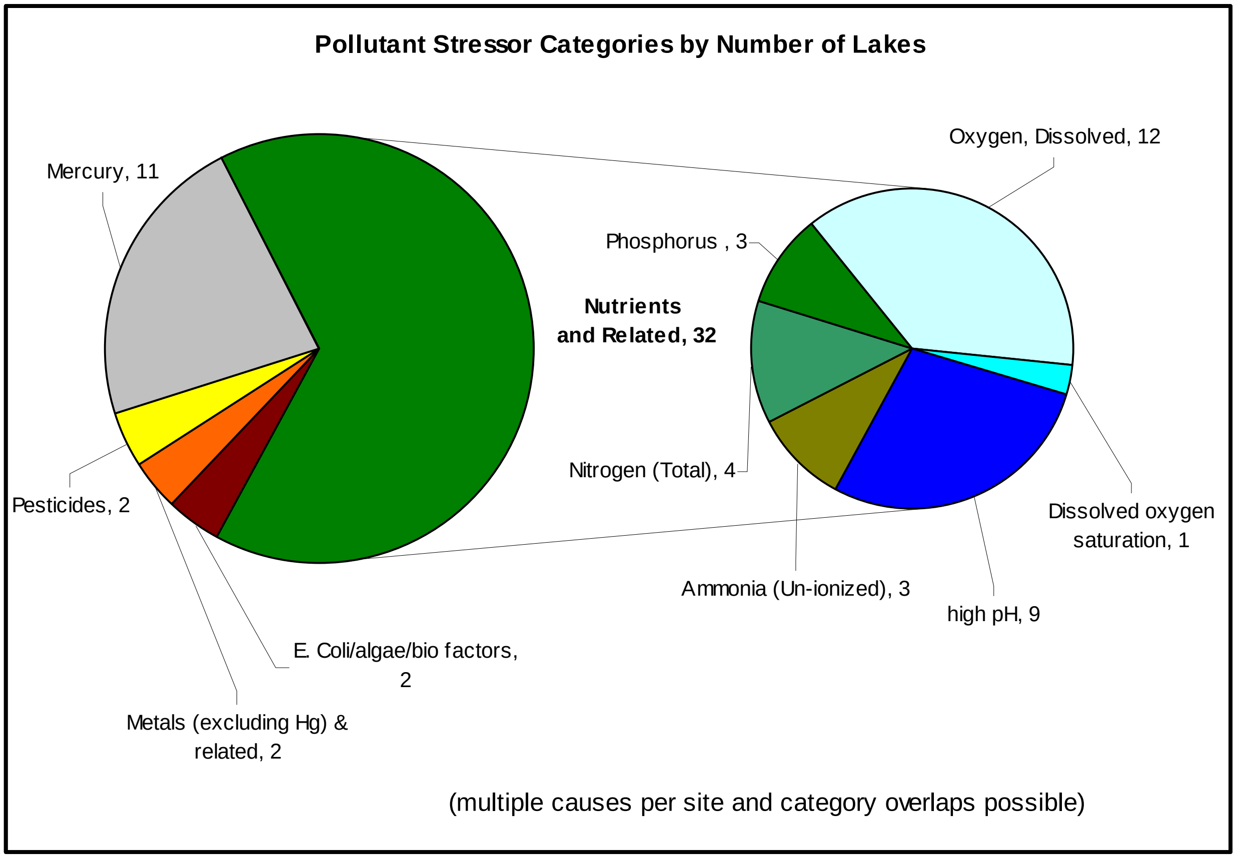
  Never drink untreated lake or stream water. At a minimum, back packers must filter and disinfect the water before drinking it.

Pollutants Causing Impairments and Probable Sources – The pollutants causing impairments are summarized in the following table and graphs.

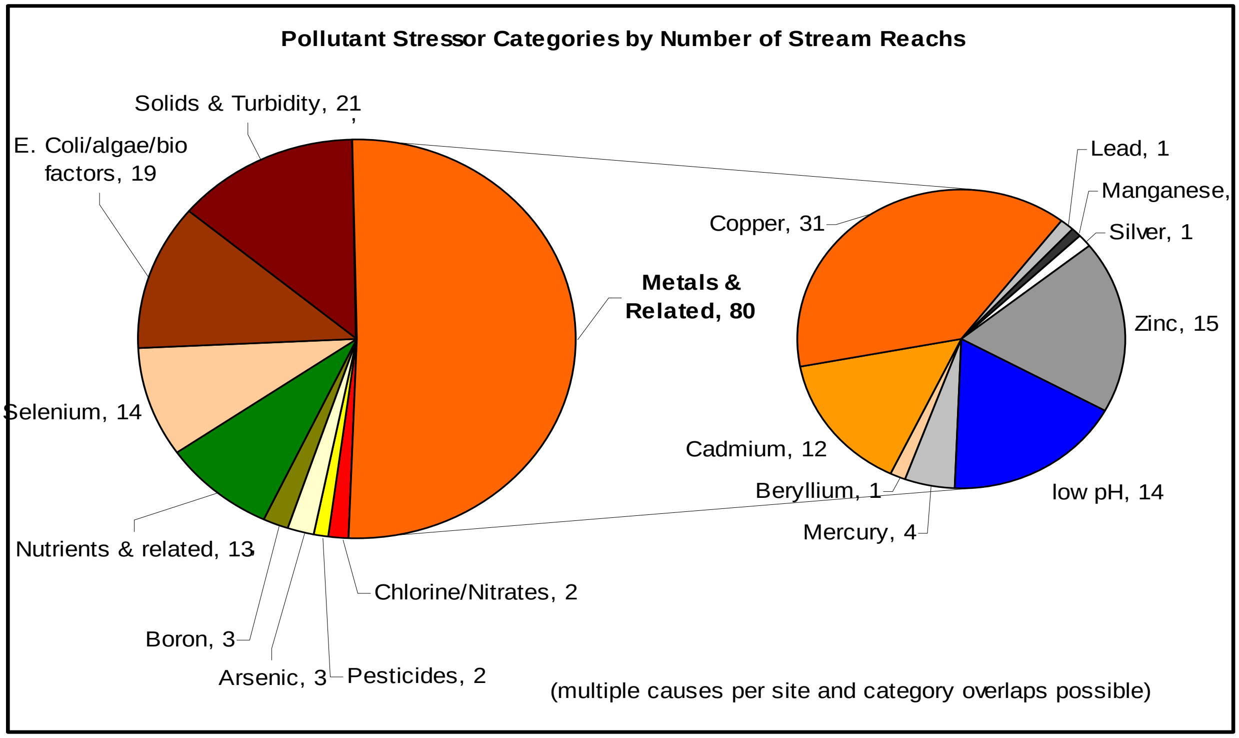
Pollutants or Stressors Causing Impairments in 2006/2008

POLLUTANT STRESSOR CATEGORY	LAKES (acres)	STREAMS (miles)
Nutrients (nitrogen, phosphorus, high pH, dissolved oxygen, or ammonia)	9,190	230
Metals (cadmium, chromium, copper, lead, silver, zinc or low pH) (Excluding mercury, boron, selenium)	62	410
Selenium	0	271
Mercury	5,341	40
Boron	0	59
Suspended sediment, turbidity, or sedimentation	0	288
E. coli bacteria	12	232
Pesticide (DDT metabolites, chlordane,toxaphene)	285	99
Other (Nitrate from explosives and chlorine)	0	22

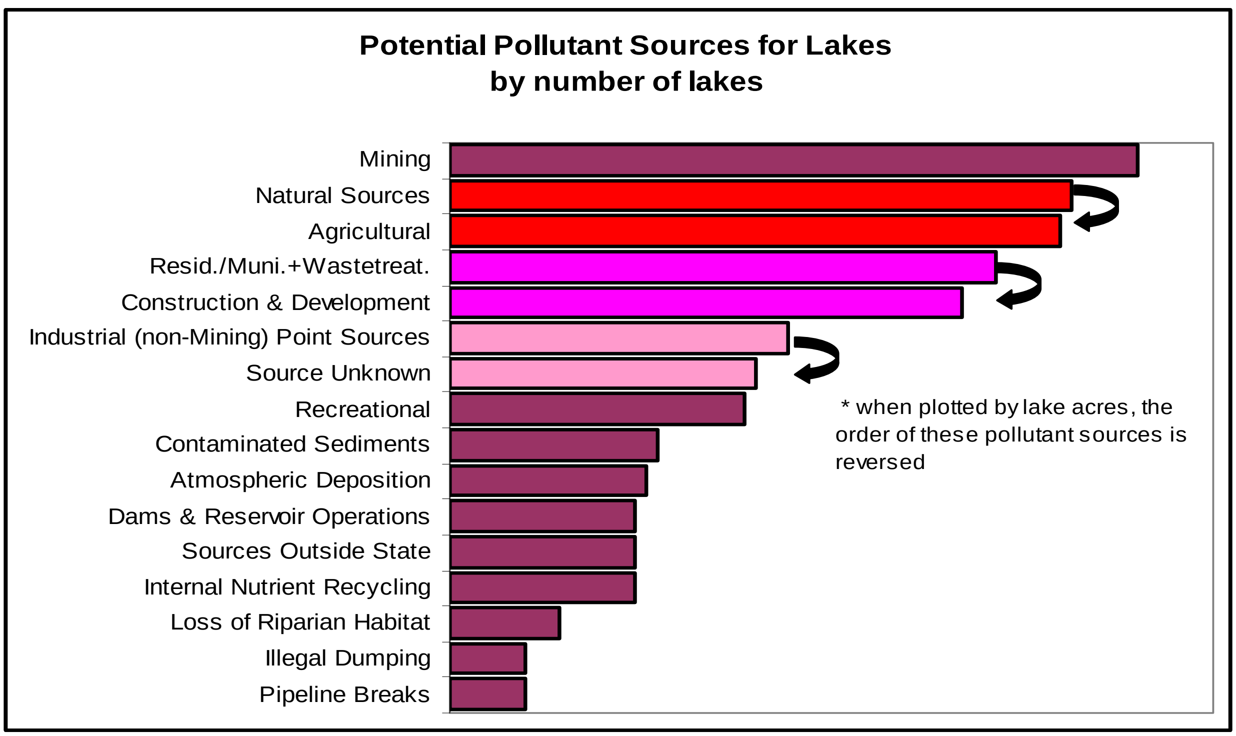
*Cannot total miles or acres because some waters are impaired by multiple stressors

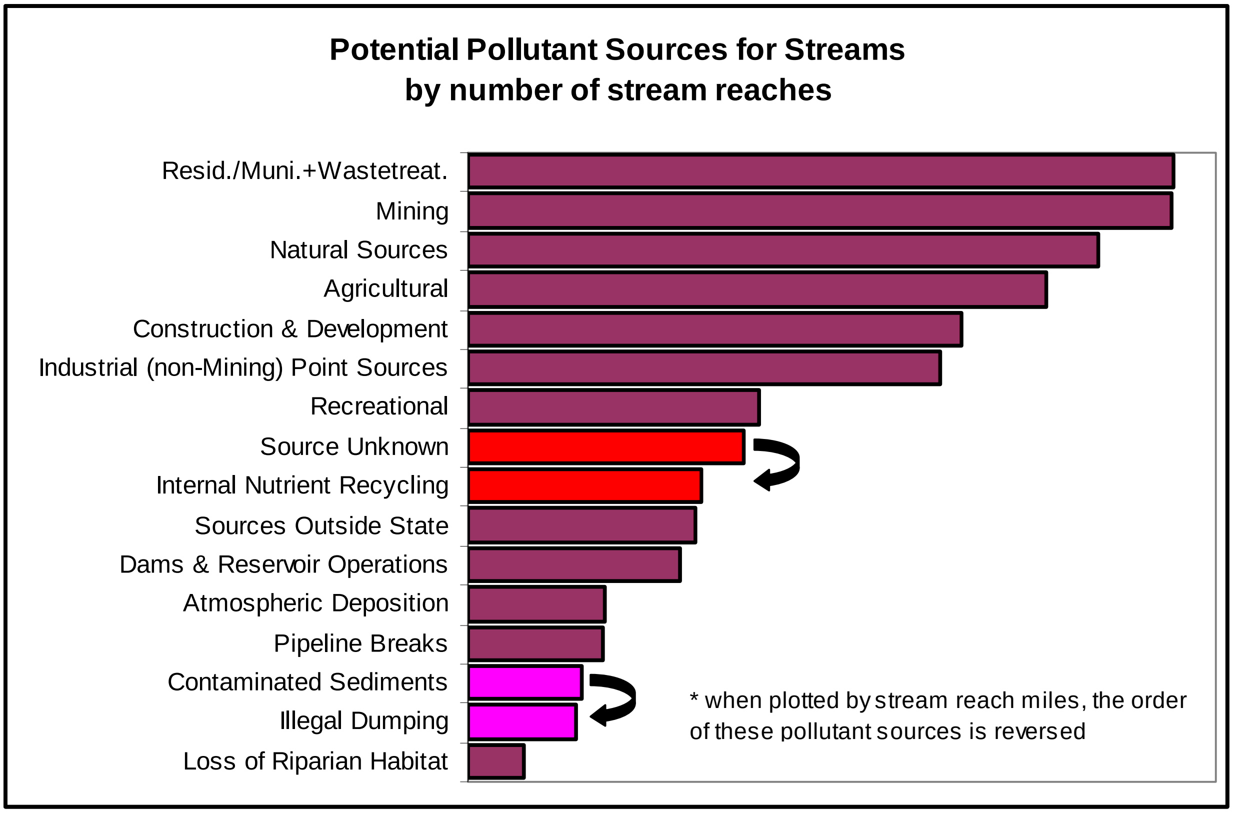


*A high percentage of Arizona's lakes are stressed by nutrient pollutants. The primary cause of impairment for lakes is high pH and the natural alkalinity of Arizona's surface waters may be contributing to this cause.



Based on past investigations, the probable sources contributing significant loadings are shown in the following tables and graphs. More than one source may be impacting a given stream reach or lake. These statistics are based on best available information, knowledge of land uses and activities in the watershed, and geology of the watershed.





Nutrient-related Impairments and Sources

Low dissolved oxygen and high pH are generally related to nutrient enrichment problems in lakes. Excess nutrients (nitrogen and phosphorus) can result in eutrophic or even hyper-eutrophic conditions, with high concentrations of algae and aquatic weeds during highly productive summer days. These conditions negatively impact recreational activities such as swimming and boating. If the algae suddenly die off, the resulting dissolved oxygen sag and high pH can result in fish kills. Excess algal growth can also impair public water supplies by imparting taste and odor problems, or by resulting in high concentrations of algal toxins.

Recent TMDL investigations have shown that the primary sources of nutrients affecting lakes and streams in Arizona are:

- Inadequate septic systems
- Inadequate toilet and waste disposal facilities in recreational areas
- Attached to sediments being transported in from the watershed (from grazing, wildlife, urban development, irrigated crop production)
- Animal wastes near the surface water (dog droppings, geese and ducks).

The potential for excess nutrient problems is further exacerbated by natural conditions, such as sunny days and hot temperatures that increase algae and aquatic plant production, nutrient cycling in the lake, and even shallow lake design and maintenance.

Pathogen-related Impairments and Potential Sources

ADEQ uses *Escherichia coli* (*E. coli*) bacteria as an indicator of pathogens in the water. While pathogens occur naturally in the environment, high concentrations of *E. coli* in waters used for swimming or even wading can pose a threat to human heath.

Pathogens are frequently attached to sediment; therefore, water with heavy sediment loads is likely to have high levels of pathogens. Flood waters carry pathogens into our surface waters at high concentrations; therefore, swimming should be curtailed during runoff events. Murky, sediment loaded water, is also difficult to effectively disinfect for drinking water purposes. This can be a problem for public systems using surface waters or for backpackers who need to filter and disinfect the water for drinking purposes.

The sources of *Escherichia coli* and other pathogens are generally the same as the sources of nutrients discussed above: inadequate septic systems, inadequate toilet and waste disposal facilities at recreational areas, sediments, animal wastes attributed to grazing, dog droppings, ducks and other animals being fed at lakes. Watershed control strategies frequently focus on restoring natural vegetation filters, reducing erosion and sedimentation, improving waste management, and improving septic systems.


Big Sandy River Storm Flow

Sediment-related Impairments and Potential Sources

Arizona adopted a suspended sediment concentration (SSC) standard in 2002 to replace its turbidity standard. The SSC criterion is intended to protect fish coldwater and warmwater aquatic communities in perennial streams. Because sediments also contain the other pollutants of concern (metals, nutrients, bacteria), reducing suspended sediment loadings is a priority.

Although some suspended sediment will occur naturally, SSC and sedimentation can be reduced by stabilizing stream banks, reducing and directing storm runoff flow, and improving the riparian conditions or constructing other vegetative filters. Watershed management strategies are being implemented in Arizona to reduce sediment loadings from construction sites, grazing, silviculture, urban development, crop production, mining, recreation (off-highway vehicles), and more.

Metals-related Impairments and Potential Sources

High concentrations of metals, especially dissolved metals, primarily pose a risk to aquatic life because even low concentrations can be toxic to critters that live in the water. Metal pollutants can impair each one of our designated uses if at a high enough concentration.


Worlds Fair Mine and Stream Below

Arizona has extensive areas of mineralized rock, and therefore, a high potential for metals pollution. Metals leach more readily from soil or mineralized rock that has been exposed by mining or even road building and land development activities. Ore bodies and springs that recharge our streams can also naturally contribute metals to our streams.

Acidic conditions occur near mining activities. The lower the pH of the water (more acidic), the more likely metals will be in their more toxic dissolved state. The more neutral or alkaline the water conditions, the more metals adhere to sediment and are less toxic. Fortunately, most of Arizona's lakes and streams are relatively alkaline. When metal-contaminated sediment is transported downstream to a lake, the water slows and the sediments drop to the bottom of the lake, where the contamination becomes buried under layers of sediment. Therefore, most metal exceedances occur near mines and seldom occur in lakes.

Mercury and selenium have a different fate and transport, so they are discussed separately.

Mercury Impairments and Potential Sources
Mercury bioaccumulates in the food chain, with top predator fish having higher mercury concentrations than forage fish. Mercury poses a serious health concern to humans and other animals that prey on fish contaminated with mercury. When the mercury concentration in the edible portion of a fish exceeds 0.3 mg/kg, ADEQ establishes a Fish Consumption Advisory for the lake, in conjunction with the Arizona Department of Health Services and the Arizona Game and Fish Department. These advisories have been issued at a number of lakes in Arizona.

Mercury is naturally present in rock formations in Arizona. If not stabilized, crushed rock mine tailings piles can erode and add mercury and other metals into the surface water. Such abandoned and inactive mine tailings piles are scattered across Arizona. Also, mercury was used in the gold mining process before the introduction of cyanidation technology at the beginning of the 20th Century. In this process mercury was used to amalgamate with the mercury. Then the mercury was evaporated off in a furnace. Some mercury loss occurred in the many steps in this process.

Significant potential point sources of airborne mercury have been shown to be the source of mercury across the United States (*Mercury Study Report to Congress*, EPA, 1997). These sources include coal-fired power plants, waste incinerators, cement and lime kilns, smelters, pulp and paper mills, and chlor-alkali factories. ADEQ is currently developing a number of mercury TMDLs for lakes and is collecting data to quantify the mercury contribution from atmospheric deposition.

Selenium Impairments and Potential Sources
Selenium bioaccumulates and can cause reproductive effects to fish and waterfowl. Selenium is a naturally occurring metalloid. It has a complex biogeochemistry in the aquatic environment as it can exist in and transform between several oxidation states, each with varying bioavailability and toxicity. It also has a very narrow concentration range between nutritional requirements and toxicity. Therefore, assessing the risk posed by selenium exceeding chronic criteria requires extensive site-specific studies, with the primary focus on documenting reproductive effects to exposed fish and waterfowl.

Anthropogenic sources of selenium in Arizona may include: irrigated agriculture return flows and drainage, combustion of fossil fuels, coal mining, sulphide ore mining (copper, lead, zinc mines) and animal feed supplements.

Pesticide-related Impairments and Potential Sources
The historic use of banned pesticides is still the primary source of pesticide contamination problems in Arizona. Banned pesticides such as DDT take a long time to degrade. Meanwhile, relatively small concentrations can bioaccumulate in the food chain, passing higher concentrations on to offspring and predators, including humans. The presence of pesticides in fish tissue has lead fish consumption advisories being posted for the Gila River, Salt River, and Hassayampa River below the Phoenix Metropolitan area down to Painted Rocks Dam. These pesticides were used on cotton and citrus fields and are transported into our streams and lakes attached to sediments from the historic crop land.

Comparison of Point Source and Nonpoint Sources of Pollutants -- Water pollution is often discussed in terms of “point” and “nonpoint” sources. Thirty years ago, federal and state regulations primarily governed point source discharges through the National Pollution Discharge Elimination System (NPDES) permit requirements. Point sources come from a discrete discharge point or pipe (e.g., a wastewater treatment plant discharge). However, pollution also comes from more diffuse sources that are referred to as “nonpoint sources,” such as runoff from urban areas, farm fields, or mining operations.


Potential for Nonpoint Source Pollution

Differentiating between point and nonpoint sources is not always clear. For example, are septic systems or stormwater runoff from mine tailings, construction sites, urban areas, or concentrated animal feeding operations considered point sources or nonpoint sources? All of these require permits. The stormwater runoff examples require an NPDES general permit. However, reductions in stormwater loadings are handled by application of nonpoint source management practices. For this assessment, these sources were differentiated as follows:

- Septic systems were considered nonpoint sources.
- Stormwater runoff from constructions sites was considered nonpoint sources.
- Stormwater runoff from urban areas was considered nonpoint sources.
- Stormwater runoff from concentrated animal feeding operations was considered a nonpoint source.
- Active mine sites that are required to obtain a general NPDES permit were considered point sources, while inactive or historic mine sites were considered nonpoint sources. For this assessment, only historic mine tailings were considered sources of impairments.

Estimated Contributions from Point and Nonpoint Sources – 2006/2008

	Point Source	**Nonpoint Source**
Streams (miles)	46	3,245
Lakes (acres)	520	30,504

*Miles include intermittent and ephemeral streams, canals, and washes.

Most pollution in Arizona’s surface waters is contributed by nonpoint or diffuse sources of pollution. This may indicate the effectiveness of the state and federal regulatory programs working with point source discharges. The control of nonpoint source contributions largely remains non-regulatory, based on education and funding of mitigation projects.

CHAPTER IV
ACTION PLAN

How do we get from assessments to water quality improvements? This chapter will discuss programs involved in mitigating water pollution problems. It will also discuss water quality research, including research into new standards, monitoring, and assessment techniques.

Impaired Waters → Now What

Monitoring and assessments are part of a process to identify impaired waters and then reduce discharges of pollutants in the watershed. Surface waters in **Appendix B** categories 4 and 5 are not attaining or impaired for their designated uses. Impaired waters that require a Total Maximum Daily Load Analysis (on the 303(d) List) are in Category 5. Waters that are not attaining a use and do not require a TMDL (at this time) are in Category 4. For example, once the TMDL is completed, the surface water is moved to Category 4A. Surface waters that are not attaining standards solely due to natural conditions are in Category 4N. If actions are being taken so that surface water standards will be met, ADEQ and EPA may agree to place the surface water in Category 4B. (See the Assessment Methods document for further information).

It is important to recognize that all waters in Category 4 and 5, even waters that are solely impaired due to natural conditions, are protected under Arizona's Antidegradation Rule (Arizona Administrative Code R18-11-107), as a "Tier 1" waters. No further degradation by that pollutant is allowed. Potential pollutant loadings must be considered by ADEQ and several federal agencies before permits or certification are issues (e.g., NPDES/AZPDES discharge permits, grazing permits).

Total Maximum Daily Load Analyses – Usually, if an assessment unit is identified as impaired, a Total Maximum Daily Load (TMDL) must be developed. A TMDL is a written analysis that determines the maximum amount of a pollutant that a surface water can assimilate (the "load"), and still attain water quality standards during all conditions.

Sources of pollutants are identified in the initial phase of the TMDL. Pollutant loading can originate from two types of sources: point and nonpoint. Point sources are discrete conveyances of pollutants discharged directly to a surface water, such as wastewater treatment plant outfalls. Nonpoint sources are non-discrete discharges, including runoff generated by activities such as grazing, agriculture, mining and forestry.

Waste load reductions from point sources can be managed through permitting programs such as Arizona's Pollutant Discharge Elimination System. However, there are few regulatory actions available to control nonpoint pollution, so load reductions from these sources are primarily voluntary. Nonpoint source pollution may include excessive sediment caused by the denudation of grasslands, the location of roads, construction, bacteria from wildlife and/or recreation, metals from historic mining practices and road cuts through ore bodies, and pesticides from historic agricultural practices.

TMDL Schedule and Prioritization – A schedule for TMDL development is provided in **Appendix C.** Criteria for this ranking is established in the Impaired Waters Rule (R18-11-606) (see Assessment Methods document). In general, waters with "high priority" factors are scheduled to be initiated within two years following EPA's approval of the 303(d) List, as these have a substantial threat to health and safety to humans, aquatic life, or wildlife. However, some "low priority" factors actually take precedence over high priority factors when completing the TMDL at this time would either not be appropriate or an effective use of resources (e.g., standard change is proposed).

The published schedule may be revised due to changes in resources to complete TMDLs or new information obtained while developing the TMDL. Such changes are formally negotiated with EPA and would be made known to the public through the TMDL status page on ADEQ's website: www.azdeq.gov.
Currently TMDLs have been approved on least 38 assessment units since 1998.

TMDL Implementation Plans (TIPs) – After load allocations are established in the TMDL, strategies must be implemented in the watershed so that these allocations will be met in the future. Normally the TIP is included in the TMDL and it identifies generic strategies, agencies or groups who will be involved in implementation, a tentative schedule, and how effectiveness will be determined. The table in **Appendix F** also indicates the status of TMDL Implementation Plan development.

Landowners, governmental agencies, nonprofit organizations, and other stakeholders are actively encouraged by ADEQ to help develop these management strategies. Implementation of strategies or projects rely on the cooperation of stakeholders that live within the watershed or have management responsibilities for the lands and the surface and ground water resources within the watershed.

Implementation on Nutrioso Creek

To reduce nonpoint source pollution, ADEQ works with federal, state, and local agencies, tribes, nonprofit organizations, the environmental community, and local citizens to develop and implement watershed management strategies. ADEQ's Nonpoint Source Program aims to address water quality issues primarily through public education and involvement – development of a commitment to watershed stewardship.

The Nonpoint Source Control Program relies on this type of cooperation, education and partnership as the primary method to reduce nonpoint source pollution and improve the state's water quality.

Watershed Partnerships – Watershed protection groups (partnerships) were first organized in Arizona by the Department of Water Resources to address water quantity issues – limited water resources, high water demands, and water rights. ADEQ is now working with these groups, along with groups established during TMDL development, to address water quality issues. Active watershed partnerships and contact information is provided in the watershed discussions in Chapter II.

Water Quality Improvement Grants – These funds (Clean Water Act Section 319(h) Funds) implement on-the-ground water quality improvement projects that address nonpoint sources of pollution. ADEQ administers these grants. Watershed Protection Funds, administered by the Arizona Department of Water Resources, also fund projects that enhance or restore surface waters, associated riparian resources and wildlife habitat. Projects that received these funds since 2000 are described in the watershed reports in Chapter II. Projects designed to reduce loadings of pollutants causing impairment are given highest priority. As documented in the table in **Appendix F**, even before a TMDL can be developed, funds are often distributed to implement projects that will reduce pollutant loadings!

The Water Quality Improvement Grant Manual provides details about the grant process. A copy of the manual and other information about this program can be obtained by contacting the grant coordinator at (602) 771-4635 or toll free at (800) 234-5677 (extension 771-6535) of from the internet at www.azdeq.gov/environ/water/mgmt/planning. Information about the Arizona Water Protection Fund can be obtained by contacting the commission at (602) 417-2400 extension 7016.

Watershed Based Plans – Watershed plans are needed to properly allocate limited resources in mitigating water quality issues. Several watershed partnerships have developed such plans, identifying critical water quality problems in their areas. A good watershed plan includes the following elements:

Critical water quality issues, probable sources of pollutants, strategies to reduce or eliminate such problems – and who will take these actions, technical and financial assistance to implement actions, a schedule (milestones), and how effectiveness will be measured.

The Nonpoint Source Education for Municipal Officials (NEMO) Project, funded by EPA, has been working with ADEQ and the local watershed groups to develop watershed based plans. Their plans go even further by adding the following elements to these watershed plans:

Characterize the watershed,
Prioritize sub-watersheds according to risk.

Watershed plans developed by NEMO can be downloaded from their web site at: www.srnr.arizona.edu/nemo.

Master Watershed Steward Program – The mission of the Master Watershed Steward Program is to educate and train citizens across Arizona to serve as volunteers in the protection, restoration, monitoring, and conservation of their water and watersheds. This new program is a partnership of the University of Arizona Cooperative Extension and ADEQ. Classes are being taught across the state.

To become a Master Watershed Steward, participants attend the required 50 hours of course and field work and provide a minimum of 40 hours of volunteer service to their communities and watersheds. Stewards learn about:

- Watersheds and hydrology
- Local geology and soils
- Arizona climate
- Water quality and quantity issues
- Regional, state, and local water management
- Mapping and geospatial technology (GPS)
- Watershed fauna and flora
- How to work together

More information can be obtained from the Arizona Extension Service at their website: cals.arizona.edu/watershedsteward.

Volunteer Monitoring – Volunteer monitoring groups can monitor the condition of surface and ground water. Gateway Community College in Phoenix, in cooperation with ADEQ, has developed a one-credit course on water quality sampling to train Arizona's volunteers and provide further opportunities for watershed stewards. Information about these classes can be obtained at the college website: environment.gatewaycc.edu/resources/volunteermonitoring/default.htm.


Monitoring Nutrioso Creek

Determining Water Quality Improvements – Once a TMDL has been developed, the surface water is removed from the 303(d) list, but usually the water is still impaired and simply moves from the Category 5 to the Category 4 list of impaired waters. To determine that a water is no longer impaired by a pollutant, ADEQ must do further monitoring. These new samples need to be collected during critical conditions – those environmental factors (stream flow, season, runoff events, location, runoff events) during which an exceedances of a water quality standard or criterion is most likely based on past exceedances or modeling results. There may also be critical locations or sites where exceedances are most likely to occur. Critical conditions and locations are identified in **Appendix E**. This list is constantly being revised as new information is analyzed.

The number of samples required to establish that a surface water is no long impaired varies by type of pollutant, but the factors are specified in the Impaired Water Identification Rule (see draft 2006/2008Assessment Methods document). The delisting criteria vary depending on the criteria used during the listing.

This assessment showed that a number of pollutants could be removed from the impairment tables. A list of pollutants no longer impairing waters and waters that are no longer impaired is provided in **Appendix D**.

Potential Impacts on Permitted Discharges – Although assessments are <u>not</u> compliance based actions, once an assessment unit is identified as impaired, there are indirect consequences on dischargers or potential activities in the drainage area. For example, any entity seeking a permit for a new discharge or renewing an existing permitted discharge under the National (or Arizona) Pollutant Discharge Elimination System (NPDES/AZPDES) Program must demonstrate that it will not increase loadings for the parameter identified as causing the impairment. During the permit review cycle, additional monitoring may be required for the pollutant of concern. If discharge monitoring data or ambient in-stream monitoring data is available from a permitted facility, it may be used to model the discharge load during the TMDL. Such data can be used to accurately quantify the contribution from waste loads. After the TMDL is completed, ADEQ may renegotiate the permit discharge levels if the TMDL indicates that a waste load reduction is necessary. Discharge monitoring and ambient in-stream monitoring is invaluable in developing realistic discharge limitations.

Another example is that federally approved actions, such as grazing permits, may also be restricted when a stream is listed as impaired, if those actions would contribute pollutant loadings. ADEQ actively coordinates with the U.S. Forest Service and the Bureau of Land Management to identify strategies that would minimize load reductions especially to impaired waters.

Future Assessments and Monitoring

Assessments are based on standards and standards are based on scientific studies. New monitoring and assessment methods being developed are based primarily on regional studies. Arizona has taken the forefront in developing physical integrity and bioassessment methods appropriate for an arid region. Current monitoring and assessment methods are discussed in detail in the Assessment Methods document (draft 2006).

The following table indicates the existing basis of water quality assessments and the assessment tools being developed. Several rule revisions are being proposed during the current Triennial Review that will provide new tools for assessments.

Future Basis of Assessments

	AQUATIC AND WILDLIFE	HUMAN HEALTH			
		Body Contact	Fish Consumption	Water Source	Agriculture
BIOLOGICAL					
Escherichia coli (bacteria)		Existing			
Narrative nutrients (chlorophyll-a, algae, phytoplankton in lakes)	Proposed standards	Proposed standards	Proposed standards	Proposed standards	
Macroinvertebrate community	Proposed standards				
PHYSICAL/HABITAT					
Narrative bottom deposits	Proposed standards				
Suspended sediment concentration	**Existing and Proposed revisions**				
Stream channel stability	Developing standards				
CHEMICAL					
Water column chemicals (nutrients, metals, pesticides, VOCs, radiochemicals, etc)	**Existing**	**Existing**	**Existing**	**Existing**	**Existing**
Tissue samples			Developing standards		
Physical chemicals (pH, dissolved oxygen, temperature)	**Existing**	**Existing**	**Existing**	**Existing**	**Existing**
Narrative nutrients (DO, pH, ammonia in Lakes)	Proposed standards	Proposed standards		Proposed standards	
Narrative toxicity	Developing implementation procedures	Developing implementation procedures	Developing implementation procedures	Developing implementation procedures	
Contaminated sediment	Need to develop standards	Need to develop standards	Need to develop standards	Need to develop standards	Need to develop standards

Probability-based Monitoring in Streams – In 2006, ADEQ began using Regional Environmental Monitoring and Assessment Program (REMAP) methods developed by EPA to determine the status and regional-scale trends in water quality in streams. These methods use statistical-based site selection and an array of analytical tests and field measurements to estimate the current status, extent, changes, and trends in water quality on a regional basis. Using this method, sites would be selected randomly, so inferences can be made concerning regional water quality based on samples collected.

The following types of analytical tests and field measurements are used at each site to provide a broad assessment of condition and stressors:

- Water chemistry – To identify stressors (e.g., nutrient enrichment, metals) and classify water type
- Physical habitat – Degradation of riparian condition, channel stability, or stream bank stability acts to reduce the complexity and abundance of aquatic habitat and aquatic species.

- Benthic macroinvertebrate assemblage – Macroinvertebrates in streams reflect overall biological integrity. They also respond differently to stressors, so it may be possible to determine the type of pollutant causing the stress.

Where appropriate, fish tissue contaminants may also be collected to measure bioaccumulation of toxic chemicals in fish and indicates regional risks to humans and wildlife.

Biocriteria Development -- ADEQ has developed methods for assessing the biological integrity of perennial, wadeable streams in Arizona. Regional reference conditions were established and used to develop macroinvertebrate indexes of biological integrity.

Index of Biological Integrity

Biological integrity is the capability of maintaining a balanced, integrated, adaptive community of organisms. This community has a species composition, diversity, and functional organization comparable to that of the natural or least impacted habitat of the region. This least impacted diversity becomes the "reference conditions" used to measure and assess water quality.

The biological integrity of a stream reach can be determined by comparing its community characteristics to those of the reference community. Currently warmwater and coldwater community indexes have been established for perennial, wadeable streams.

The following reports have been produced by the Biocriteria Program and can be obtained by contacting ADEQ at (602) 207-4543 or on-line at the ADEQ website at www.azdeq.gov/environ/water/assessment/bio.html:

- ***Using Ecoregions for Explaining Macroinvertebrate Community Distribution Among Reference Stream Sites in Arizona***
  Patrice Spindler, ADEQ (1996)
  This study provides a classification system for warmwater and coldwater communities based on elevation to differentiate among aquatic communities in Arizona.

- ***Macroinvertebrate Community Distribution Among Reference Sites in Arizona***
  Patrice Spindler, ADEQ (2001)
  A "regional reference site" approach to bioassessments, based on warmwater communities below 5000 foot elevation and coldwater communities above 5000 feet.

- ***Biocriteria Program Quality Assurance Program Plan (QAPP)***
  Patrice Spindler, ADEQ (2006, in-press)
  Documents the bioassessment methods and protocols ADEQ is following. These methods need to be used when collecting samples in order to use the macroinvertebrate Index of Biological Integrity. Methods for measuring physical-habitat to support bioassessments are also included in this document.

- ***Development and Testing of a Biological Index for Warmwater Streams in Arizona***
  Gerritsen and Leppo, Tetra Tech Inc. (1998)
  This provides the statistical support for Arizona's warmwater macroinvertebrate Index of Biological Integrity -- perennial, wadeable streams below 5000 feet elevation.

- ***Development and Testing for Biological Index for coldwater Streams in Arizona***
  Leppo and Gerritsen, Tetra Tech, Inc. (2000)
  This provides the statistical support for Arizona's coldwater macroinvertebrate Index of Biological Integrity – perennial, wadeable streams above 5000 feet elevation.

- ***Stream Channel Morphology and Benthic Macroinvertebrate Community Associations in the San Pedro River and Verde River basins of Arizona, 1999-2002***
  P. Spindler (2004)
  This study evaluated relationships between stream channel geomorphology measurements and the metrics that describe the macroinvertebrate community. The study found that the macroinvertebrate community responded to particle size changes and embeddedness of the substrate, with loss of taxa or shifts to more tolerant taxa at low levels of fines in the Verde and moderately high levels in the San Pedro River basin. Macroinvertebrate communities respond to sedimentation but the sensitivity may be different between hydro-physiographic provinces across Arizona.

- ***Narrative Biocriteria Standard Implementation Procedures for Wadeable, Perennial Streams***
  Patrice Spindler and Steve Pawlowski, ADEQ (Draft 2006)
  Documents ADEQ's approach to determining an exceedance of the narrative biocriteria standard for wadeable, perennial streams based on a warmwater and coldwater Indexes of Biological Integrity. ADEQ will use the 25^{th} percentile of reference condition as the minimum threshold needed to attain the biocriteria standard. A verification sample will be required when the Index score falls between the 10^{th} and 25^{th} percentiles of reference conditions.

- ***Index of Biological Integrity Technical Support Documentation for the Narrative Biocriteria Standard***
  Patrice Spindler, ADEQ (Draft 2006)
  This document provides a detailed rationale for development and selection of metrics and thresholds for the Indexes of Biological Integrity.

Physical Integrity Criteria Development -- The physical integrity of a stream channel means that a dynamic equilibrium in stream channel stability is maintained over time. Rosgen (1996) provides a good definition of dynamic stability which can be defined as the ability of a stream to carry the water and sediment of its watershed while maintaining a stable dimension, pattern, and profile such that, over time, stream channel features are maintained and the stream system neither aggrades nor degrades. Dave Rosgen has developed a system for classifying streams into one of seven stream types and assessing stream channel stability, including bank stability. ADEQ is testing and calibrating Rosgen's channel stability assessment methods for use in evaluating physical integrity conditions in Arizona streams.

Bed Load Monitoring

These classification and assessment methods are being applied and tested in Arizona's streams and have lead to the following publications:

- ***Regional Relationships for Bankfull Stage in Natural Channels for Central and Southern Arizona***
  Moody and Odem (1999)
  Sites on perennial, intermittent, and ephemeral streams in central and southern Arizona were chosen to determine regional relationships of bankfull stage in natural channels. Watershed area and channel characteristics (width, depth, cross-section) were used to create "regional curves." These regional curves can then be used to identify bankfull in any other natural channel. Bankfull determinations are necessary for classifying streams according to Rosgen (1996).

- ***Integrating Regional Relationships for Bankfull Stage in Natural Channels of Arizona and New Mexico***
  Moody, Wirtanen, Knight, and Odem, Northern Arizona University (2000)
  This report integrates data from 139 study sites in Arizona and New Mexico to create regional curves for shared surface water drainages and ecoregions. These curves are the broad-scale regional curves that are currently used by ADEQ monitoring programs.

- ***Validating the Bank Erodibility Hazard Index in Central and Southern Arizona***
  Moody, Wirtanen, and Yard (2003)
  The purpose of this research document was to test and calibrate Rosgen's "Bank erodibility hazard index (BEHI)" for use in Arizona. This tool is an integral part of the Rosgen stream stability assessment method. The analysis found that the BEHI model produced reasonably accurate predictions of annual bank erosion when compared with measured erosion rates at more than 40 sites in the San Pedro and Verde River basins.

- ***Channel Stability Assessment of Biocriteria Sites in the Verde River Watershed***
  Moody, Wirtanen, and Yard (2003)
  This analysis documents the first application of the complete Rosgen stream channel stability assessment methodology to streams in Arizona. It provides physical integrity assessments for 10 sites in the Verde River Basin and recommendations for further research in calibrating the Rosgen method for Arizona.

- ***Lower Cienega Creek Restoration Evaluation Project: an Investigation into Developing Quantitative Methods for Assessing Stream Channel Physical Condition***
  Lin Lawson and Hans Huth, ADEQ (2003)
  This research effort evaluated a 10-mile reach of the Lower Cienega Creek basin for potential stream stabilization projects and developed quantitative techniques for assessing physical stream channel condition. Quantitative techniques used to evaluate sedimentation included the "Linear habitat complexity index" and "pool facet slope".

- ***Comparative Sediment Rating Curves for Two Gage Stations in the Upper Salt River Basin of Arizona***
  Patrice Spindler, ADEQ (2005), Wetlands VIII Grant from EPA
  This research effort evaluated whether sediment rating curves could be used to compare "reference" and study sites to set sediment load reduction targets in sediment impaired streams. However, during the study period, the flows for Beaver Creek (the impaired stream) were only 40% of flows in West Fork of Black River (reference stream), so less sediment transport occurred in Beaver Creek due to low flow. The study showed that sediment loads can be accurately and comprehensively estimated using remote automatic sampling of turbidity and flow data at gaging stations.

- ***Draft Fluvial Geomorphology Field Survey and Assessment Procedures***
  ADEQ (2004)
  Field methods for conducting stream surveys and Rosgen stability assessments are provided in this draft document.

- ***A Manual of Procedures for the Sampling of Surface Waters in Arizona***
  Lin Lawson (2005)
  Currently used field procedures for conducting water quality, biological and physical integrity/geomorphology/Rosgen surveys are provided in this new methods document.

- ***Narrative Bottom Deposits Standard Implementation Procedures***
  Patrice Spindler and Steve Pawlowski, ADEQ (Draft 2006)
  This paper documents ADEQ's approach to determine compliance with the narrative bottom deposits surface water quality standard in Arizona Administrative Code R18-11-108(A)(1). Exceedances will be determined based on the percentage of fine sediments (<2mm) in riffle / run habitats in perennial streams using a Wolman pebble count procedure. An exceedance occurs when the percentage of fines in riffle habitats is >35%. An exceedance also occurs if the percentage of fines in the riffle habitats is between 20% and 35%, and a bioassessment index score indicates impairment of a biological community.

- ***Analysis of Water Quality Functions of Riparian Vegetation***
  Engineering Science (1994)
  This is a technical review of existing scientific knowledge on the functional roles of riparian vegetation in controlling surface water quality and characteristics of the riparian or wetland type that enables it to perform each function.

- ***A Guidance Document for Monitoring and Assessing the Physical Integrity of Arizona's Streams***
  Graf and C. Randall (1998)
  Basic scientific principles for understanding and describing physical integrity in terms of indicator measurements: channel width, cannel depth, channel gradient, hydraulic roughness, flow velocity, water discharge, sediment discharge, sediment particle size, channel sinuosity, channel pattern, shear stress, stream power, and bankfull conditions.

Narrative Nutrient Implementation Procedures Development – In response to EPA's National Nutrient Strategy, ADEQ is revising nutrient standards. It is starting with nutrients for lakes and reservoirs, as these waters are more likely to be impaired by nutrients than streams. ADEQ also needed to develop clear implementation procedures to apply the narrative nutrient standard in Arizona Administrative Code R18-11-108(A)(7).


Roosevelt Lake

To derive and implement nutrient criteria, lakes were separated into categories based on natural or inherent characteristics that cause lakes to respond to nutrients in a similar manner, and secondly, based on similar management objectives and public expectations. The following lake categories will be used in conjunction with lake nutrient standards:

- Deep lakes and reservoirs – Average depth over 18 feet.
  - These deep reservoirs have low nutrient and chlorophyll-a concentrations and higher Secchi depths (clarity), probably due to relatively high flushing rates, deep settling of nutrients, and sedimentation in upstream reservoirs.
- Shallow lakes – Average depth less than three meters, maximum depth of four meters.
  - These lakes are susceptible to macrophyte domination because much of the lake bottom is in the photic zone (light available). Such lakes can have relatively high Secchi depths and low-moderate chlorophyll-a concentrations.
- Urban lakes – Lakes in urban settings.
  - Urban lakes have different management objectives than other lakes. For example, they are not used or water supply or for swimming. They may have high sediment and nutrient loads from urban land uses that are impractical to control completely. Urban lakes generally have relatively poor clarity, and high chlorophyll-a and nutrient concentrations.
- Igneous and sedimentary lakes – The remaining lakes
  - These lakes are managed primarily for fishing and other recreational purposes. Data indicates that igneous watersheds are more likely to experience high chlorophyll-a and nitrogen concentrations than sedimentary lakes.

Work on developing nutrient standards has lead to the following publications:

- ***Draft - Potential Nutrient Related Targets for Lakes and Reservoirs in Arizona***
  Malcolm Pirnie, Inc for ADEQ (2005)
  Derivation of numeric nutrient water quality targets to assess lakes. Uncertainty and variability in relations

between nutrients, response variables, and designated uses was addressed by expressing the nutrient targets as a range. These nutrient targets are to be incorporated into the narrative nutrient implementation guidance document.

- **Statistical Modeling Analysis Report of Lakes and Reservoirs**
  Malcolm Pirnie, Inc for ADEQ (2004)
  This report provides the statistical basis for the narrative nutrient matrix and the lakes classification. Results can be used to determine realistic and appropriate water quality targets for different lake categories.

- ***Narrative Nutrient Standard Implementation Procedures for Lakes and Reservoirs***
  Susan Fitch, ADEQ (2006)
  This paper documents ADEQ's approach to determining and exceedance of the narrative nutrient standard in Arizona Administrative Code R18-11-108(A)(7). An exceedance is determined based on a matrix of threshold values for: chlorophyll-a, Secchi depth, blue-green algae, phosphorus, nitrogen, dissolved oxygen, and pH. In most cases, supporting evidence is needed to determine an exceedance.

- ***An Exploration of Nutrient and Community Variables in Effluent Dependent Streams in Arizona***
  David Walker (University of Arizona), Christine Goforth (University of Arizona), and Samuel Rector (ADEQ). EPA Grant Number X-828014-01-01 (2006)
  Samples were collected from five effluent dependent waters (EDWs) in 2003 – 2004. Each site was sampled once during the summer and winter, as close to the respective effluent outfalls as possible, and at some distance downstream. The downstream site was determined by attempting to find a recovery zone where dissolved oxygen increased to "normal" levels, although a recovery zone was not found in some of these EDWs.

  Diversity and pollution tolerance of aquatic macroinvertebrate assemblages are inversely related to increasing levels of pollutant loading to the receiving stream. Elevated concentration of reduced and organic forms of nitrogen, combined with low levels of dissolved oxygen, were of particular detriment to macroinvertebrates.

Other Studies and Projects

- **A Manual of Conservation Practices to reduce Pollution Loads Generated from Nonpoint Sources**
  Tetra Tech, Inc and Natural Channel Design, Inc (2004)
  The implementation appendix is a manual designed to assist landowners, managers, and technicians in adopting effective and appropriate practices to reduce nonpoint source pollutants entering streams and watercourses. In general practices described are meant to be implanted in areas immediately adjacent to the surface water; however, some treatments can be utilized effectively in uplands and other areas.

- **Assessment of Selected Inorganic Constituents in Streams in the Central Arizona Basins Study Area, Arizona and Northern Mexico, through 1998**
  David W. Anning, U.S. Geological Survey, Water-Resources Investigations Report 03-4063 (2003)
  Stream properties and water chemistry constituent concentrations were analyzed to assess water quality, determine natural and human factors affecting water quality, and compute stream loads in the Central Arizona Basins study area. Data was collected at 41 sites through 1998.

- **Use of Sediment Coring to Analyze Past Response to Disturbance**
  David Walker and Owen Davis - University of Arizona and Paul Gremillion – Northern Arizona University (Start project in 2006)
  To collect core samples from Roosevelt Lake to quantify long-term water quality trends in Roosevelt Reservoir and the Salt River watershed. The project will also determine how these watershed variables define water quality within the reservoir and how aquatic biota respond to these water quality changes.

- **Algal Toxins in the Salt River Reservoirs**

David Walker – University of Arizona , Paul Zimba – USDA, and Jo Ann Burkholder – North Carolina State University. (Start project in 2006)
Monitoring of algal and cyano-toxins in all of the Salt River Reservoirs (Roosevelt, Saguaro, Canyon, and Apache lakes) is to be expanded into a study of environmental factors needed to encourage toxin production in algae.

- **Effects of Endocrine Disrupting Compounds and Pharmaceuticals on Fish**
  David Walker (ag.arizona.edu/limnology/0306report.pdf)
  Examining the effect of endocrine disrupting compounds and pharmaceuticals left in treated wastewater effluent on relatively pollution-tolerant fish (bonytail chub) has shown that sever detrimental impacts on the population is likely due to significantly lowered 17B-estradiol levels in female fish. The study also found feminization of male fish. Very low concentrations of typical wastewater compounds were present (e.g., nutrients) in the treated effluent. Results are to be presented at the National Groundwater Associations 5th International Conference on Pharmaceuticals and Endocrine Disrupting Chemicals in water on March 13, 2006.

- **Draft Guidance for Implementing January 2001 Methylmercury Water Quality Criterion**
  EPA (August 2006)
  This document describes methods for measuring mercury and methylmercury in both tissue and water samples. This document describes how to interpret the data collected and assess designated use support.

- **Monitoring Mercury Deposition**
  Jennifer Hickman – ADEQ
  Arizona's first Mercury Deposition Network (MDN) site is being established along Sycamore Canyon, in the Raymond Boy Scout Camp near Parks, Arizona to help quantify mercury deposition. This data will be used in the development of mercury TMDLs. More information can be obtained by contacting Jennifer Hickman at: (602) 771-4542.

- **Implementation Guidance for Ambient Water Quality Criteria for Bacteria**
  U.S. EPA (November 2003 Draft)
  This document provides recommendations on the implementation of bacteria criteria for the protection of recreation uses. It provides explanations of how to assess and determine attainment of water quality standards, develop subsequent TMDL loads/wasteload allocations, and how recreational water quality criteria should be used in NPDES permits.

- **Organochlorine Compounds in Streambed Sediment and in Biological Tissue from Streams and Their Relations to Land Use, Central Arizona**
  J.B. Gebler – National Water Quality Assessment Program, U.S. Geological Survey
  The objective of the study was to determine the occurrence and distribution of organochlorine compounds (pesticides) and their relation to land use in central Arizona. Sediment samples were collected at 13 sites, and biological tissue samples at 11 sites. The greatest number of compounds and highest concentrations of many contaminants were detected at agriculture/urban sites. The compound detected most frequently in sediment and tissue samples was p,p'-DDE (a DDT metabolite).

- **Selenium – Fate and Effects in the Aquatic Environment**
  Peter M. Chapman, EVS Environment Consultants
  Proceedings of the 24th Annual British Columbia Mine Reclamation Symposium – The Technical Research Committee on Reclamation (2000)
  Series of studies by the Arid West Water Quality Research Project
  Pima County Wastewater Management, www.pima.gov/wwm/wqrp (2004)
    - Extant Criteria Evaluation – Objective to examine the appropriateness of Arizona's Water Quality Criteria for western ecosystems, identify weaknesses, and recommend further research to address weaknesses.

- Discharge Survey – Gather information to identify the nature of existing arid west surface waters receiving wastewater discharges, and species or habitats that are affected by discharges to these waters.
- Evaluation of the Reliability of the Biotic Ligand Model Predictions for Copper Toxicity in Waters Characteristic of the Arid West – A series of studies to evaluate the appropriateness of the Biotic Ligand Model to determine copper toxicity in Arizona's hard water.
- Habitat Characterization Study – Documents the physical, chemical, and biological characteristics of 10 effluent dependent waters in the arid west.
- Evaluation of Whole Effluent Toxicity Testing as an Indicator of Aquatic Health – This pilot study was designed to determine: 1) Which biological assemblages should be sampled to assess effluent impacts, 2) What are the appropriate sampling methods for macroinvertebrates and should the methods vary with the type of hydrological setting, 3) Are the proposed data and measurement quality objectives achievable on a regular basis.

Progress and Accomplishments

Are these actions working? Are we progressing or even holding our own if we continue to identify impaired waters? Can we measure effectiveness or success?

The Association of State and Interstate Water Pollution Control Administration (ASIWPCA) is asking each of the states to look for indications of progress since the 2002 listing cycle. Most of the following performance measures were chosen by ASIWPCA to evaluate national progress, but can also provide some indication of how well Arizona's monitoring and assessment programs are working.

Evaluating Progress in Monitoring and Assessment Programs – Changes in the amount of surface waters assessed is one way to evaluate ADEQ's Assessment and Monitoring Programs. The following tables show the stream miles and lake acres assessed in 2002, 2004, and 2006/2008.

These tables exclude the surface waters assessed in Category 3 (all uses "inconclusive") because by default any water not assessed would belong in this category. The assessment shows some surface waters in this category – those with any current assessment information – but no attempt is made to include all of the other waters that belong in this category, as many are unnamed washes.

Total Waters Assessed

	LAKES				STREAMS		
	2002	2004	2006/2008		2002	2004	2006/2008
	Acres				Miles		
Estimated Waters	289,630	289,630	295,590*		90,375	90,375	90,375
Waters Assessed*	40,948	67,340	88,672		1,671	2,227	2,806
Percent Assessed	14%	23%	30%		2%	2.5%	3%

*Waters Assessed excludes Category 3 – all uses assessed as "inconclusive"
*Estimated lake water size increased due to enlargement of reservoirs.

The Total Waters Assessed table (above) indicates that a very low percentage of the state's surface waters are assessed. This is primarily because the majority of waters in Arizona are ephemeral (flowing in response only to precipitation events) and not easily sampled or assessed. The Total Perennial Waters Assessed table (below) adjusts for this. Monitoring is clearly focused on perennial waters (waters that flow year round). Monitoring ephemeral and intermittent waters is limited to special investigations, such as TMDL development.

Total Perennial Waters Assessed

	LAKES				STREAMS		
	2002	2004	2006/2008		2002	2004	2006/2008
	Acres				Miles		
Estimated Perennial Waters in Arizona	168,590	168,590	174,558*		3,530	3,530	3,530
Perennial Waters Assessed*	39,873	66,264	87,773		1,405	2,081	2,685
Percent Assessed	24%	39%	50%		40%	59%	76%

* Perennial Waters Assessed excludes Category 3 – all uses assessed as "inconclusive"
*Estimated lake water size increased due to enlargement of reservoirs.

As shown in the Perennial Waters Assessed table (above), a steady increase in the percent of perennial surface waters has been occurring. Also, by comparing the total waters assessed (first table) with the total perennial waters (second table), one can see that the number of miles assessed as "inconclusive" has decreased.

Another way to look at the effort and effectiveness of these programs is to look at the number of lakes and stream reaches assessed. This is particularly revealing with lakes, as their sizes vary from less than an acre to 27,045 acres. Therefore, monitoring and assessing 20 small, but significant lakes might account for fewer acres than one large reservoir.

Assessment Units Assessed

	LAKES				STREAMS		
	2002	2004	2006/2008		2002	2004	2006/2008
	Lake Assessment Units				Stream Assessment Units		
Waters Assessed	40,948 acres	67,340 acres	88,663 acres		1,671 Miles	2,227 Miles	2,801 Miles
Assessment Units	30 units	51 units	79 units		137 units	172 units	298 units

(Excluding Category 3 – all uses assessed as "inconclusive")

The Assessment Units Assessed table (above) reveals that the number of lakes and stream reaches being successfully assessed as either "attaining" or "impaired" and been increasing steadily.

Although we could also look at changes in the number waters assessed as impaired, how should such statistics be judged? Does a decrease in impaired surface waters indicate that water quality is improving, or simply that there has been a change in assessment criteria or standards? Is listing additional waters as impaired success or failure? If the goal is to find more waters are attaining their uses, then monitoring can be targeted in more pristine waters, but does that fulfill ADEQ's goal to improve and protect water quality and natural resources? Due to these issues, ADEQ does not evaluate its Assessment, Monitoring, or even TMDL Program by the number of surface waters assessed as "impaired" or even "attaining."

Delisting Pollutants and Water Quality Improvements – The primary goal of ADEQ's water quality programs is to improve and maintain water quality in Arizona. One way to measure whether ADEQ is achieving its goal to improving water quality is look at the number of stream miles or acres "no longer impaired" (delisted). (Delistings during this cycle are shown in **Appendix E**.)

For this analysis, pollutant impairments are counted rather than the miles or acres. "Pollutant impairments" are the number of pollutants listed multiplied by the number of assessment units listed. For example, if arsenic, cadmium, chromium, copper, zinc, and pH (5 pollutants) were listed for 3 reaches of Pretty River, it would be counted as fifteen "pollutant impairments." The following table shows the number of pollutant impairments removed, using the 1989 list as the baseline for this evaluation.

Pollutants No Longer Impairing Surface Waters

		2002 ASSESSMENT	2004 ASSESSMENT	2006/2008 ASSESSMENT
TOTAL POLLUTANT IMPAIRMENTS		260	195	230
REASONS FOR DELISTING	NEW STANDARD	--	15	--
	NEW ASSESSMENT CRITERIA	81	--	--
	WATERSHED IMPROVEMENTS	22 (Gila, Munds, Pinal)	4 (Mineral, Tempe)	1 (Nutrioso)
	NEW DATA, NO WATERSHED IMPROVEMENTS	12	4	9
	NATURAL CONDITIONS	8	--	--
	OTHER	2	--	--
TOTAL DELISTED		125	23	10

The delistings in 2002 were primarily due to changes in assessment criteria that occurred when the Impaired Waters Rule and TMDL Statute were adopted. The 2004 assessment reflected new surface water quality standards (e.g. replacing the turbidity standard with a standard for suspended sediment concentration). In the current assessment (2006), delistings were primarily the result of new monitoring data showing that the standards are now being met. In only one case improvements in the watershed were demonstrated. The other delistings may be associated with intermittent pollutant loadings and drought conditions reducing pollutant loadings. Improved water quality monitoring and analysis techniques also lead to delisting at least one reach.

Over the past 3 assessments, water quality improvements have been clearly documented in only a few areas:

- Lake Havasu – Bacteria contamination at beaches in Thompson Bay were significantly reduced by implementation of strategies to increase stream flow in this back bay area, increase sanitary facilities available at the beaches, and decrease nutrient loadings from wastewater facilities (1 pollutant impairment).
- Middle Gila Pesticide Contamination Area – Dieldrin concentration in fish tissue samples dropped below detection limits after a ban on its general use for many years in Arizona. The fish consumption advisory remains in place due to DDT, toxaphene, and chlordane contamination of fish and other edible aquatic life in this area (12 pollutant impairments).
- Mineral Creek – Surface water contamination has been mitigated by extensive surface water remediation actions at mining operations along this creek (3 pollutant impairments).
- Munds Creek – Improvements in effluent reuse practices resulted in *E coli* bacteria, nitrogen, and phosphorus reductions (3 pollutant impairments).
- Pinal Creek – Extensive groundwater and surface water remediation and treatment near mining operations has resulted in significant water quality improvements (6 pollutant impairments).
- Nutrioso Creek – Grazing practices have been improved along one reach resulting in reduced sediment loading to the stream (1 pollutant impairment).
- Tempe Town Lake – A lake management plan was successfully implemented to control algal growth (that resulted in high pH) in this constructed lake (1 pollutant impairment).

Why so few documented water quality improvements? Many reasons contribute to this being a slow process, such as: most improvements require voluntary actions, the high costs to implement many actions, vast size of drainage areas containing large numbers of individual sources, and source contributions from other states, Mexico, and occasionally tribal lands. Even when actions are applied within a watershed, it may take years to see reductions in erosion. Recognizing the difficulties faced, these few documented improvements can be celebrated!

Progress in Completing and Implementing TMDLs – The number of TMDLs and implementation plans (TIPs) completed is another measure of how far we have progressed in the process of remediating water quality problems.

TMDL Progress – By Pollutant Impairments

	Assessments					
	1990- 2002	2002	2002-2004	2004	2004-2006	2006
TMDLs Scheduled		175		131		168
TMDLs Approved	63		83		18	
TMDL Implementation Plans Completed	63		83		18	
TIP Strategies Being Implemented	62		53		15	
Alternative to TMDL – Management Plan	--	1		0		1

Clearly progress is occurring in developing TMDLs and their implementation plans. However, the number of TMDLs dropped during the past two years for several reasons. The Department is taking on more complex TMDLs. State budget constraints lead to staff turnover and delays in replacing staff. Drought conditions have slowed sample collection on ephemeral and intermittent streams. What this table does not indicate is that the Department is in the later stages of several complex TMDLs, such as: Lake Mary regional mercury TMDL, Alamo Lake regional mercury TMDL, Oak Creek Phase II bacteria TMDL, Pinto Creek Phase II copper TMDL, and the Mule Gulch copper TMDL.